BEAM INSTABILITIES MEASUREMENT AND CURES AT HLS*

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Abstract
In Hefei Light Source (HLS), coupled-bunch instabilities are major limiting factors in achieving higher beam intensity while maintaining good beam quality. To measure and suppress beam instabilities, turn-by-turn (TBT) measurement and bunch-by-bunch (BxB) measurement & feedback system are under commission [1][2]. The design of the two systems and primary experiment results is presented. Measurement and detail analysing results in injection status will also be shown.

INTRODUCTION
HLS is a synchrotron light source injecting in the energy of 200MeV and operating in 800MeV, which operates with 45 bunches in 204.016MHz RF. The circumference of electron storage ring is 66 meters. A multi-cycle multi-turn injection system is used for current accumulation. The maximum electron current is presently limited to about 250mA due to multi-bunch instabilities. Those are observed especially at injection and energy ramp by turn-by-turn and bunch-by-bunch measurement system. The implementation of a transversal bunch-by-bunch feedback system is necessary.

SYSTEM DESCRIPTION

TBT Measurement System
HLS Turn-by-turn system consists of front end pick-up electrodes mounted in a skew 45°, Log-ratio electronics, timing system, and data acquisition system. The log-ratio processor works at 408MHz which is 2* RF of HLS[3].

BxB Measurement and Feedback System
The transverse bunch-by-bunch feedback system of HLS is based on designs for PLS[4]. An optical-fiber two-tap FIR filter[5] and a new feedback cavity have been developed for this system. This system is integrated with longitudinal oscillation measurement system, fast vector control, fiber notch filter and bunch current detection system.

BXB FEEDBACK AND MEASUREMENT SYSTEM TIME-SETTING TUNE
With the using of new optical-fiber two-tap FIR filter and new feedback cavity, setting of the timing of feedback systems need readjustment. For better timing and bunch identification the number of bunches in the storage ring was reduced to single bunch in one train. Because of multi-cycle multi-turn injection system, a resonant knockout generator was used, which allowed the deleting of discrete bundles in the train after the injection is completed. Figure 3 show the single bunch signals recorded by an oscilloscope: C1 is bunch position signal, and C2 is the amplified feedback signal and the signal induced in the feedback cavity strip-line by the beam.

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200 MEV INJECTION INSTABILITIES MEASUREMENT

One aim of building this feedback system is to improve the maximum accumulation electron current at injection status. So, recording the bunch-by-bunch beam position data is very important when electron current reach the limit and not accumulate anymore. With turn-by-turn and bunch-by-bunch measurement system, we can observe injection instabilities at real time and can know whether multi-bunch instabilities are effectively cured.

The bunch-by-bunch transverse position tracing shows in Figure 4, from which injection damping can be clearly recorded. Injection signal is provided to measurement system as trigger.

From data of figure 4, we can get the frequency map, phase information, bunch motion in mode space of each bunch.

While injecting, longitudinal and transverse oscillation are much intense. Detail analysing result of bunch-by-bunch transverse position tracing is showed from figure 5 to figure 8.
800 MEV FEEDBACK READJUSTMENT

To adjust the feedback phase, two BPM are selected to just the feedback signal. DBM (double balance mixer) can supply not only a positive adjustable attenuate factor, but also a negative adjustable attenuate factor. It is a great upgrade of the flexible of this feedback system. Compare with the 90 degree adjust range, this method can support 360 degree feedback signal vector calculating.

Feedback Phase Readjustment

Figure 9 and 10 show the Synchrotron beam profile and corresponding bunch-by-bunch frequency spectrum. With in-phase signal, the feedback system is used to cure the beam instabilities, and anti-phase is to excite.

EXPERIMENT CONCLUSION

To now, with the optical-fiber two-tap FIR filter and a new feedback cavity, we only have readjusted time-setting and feedback phase at 800MeV operation status, have measured the bunch-by-bunch tracing data at 200MeV injection. The next we need to do is readjust the feedback phase at 200Mev injection status, and cure the coupled bunch instabilities at injection and increase the current to rather high values.

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REFERENCES


Figure 8: Oscillation frequency

Figure 9: Synchrotron beam profile, part a) feedback off status, part b) feedback on with anti-phase

Figure 10: frequency spectrum, part a) feedback off status, part b) feedback on with anti-phase